

OPINION

Environmental Statistics – It doesn't add up!

Given the enormity and pervasiveness of environmental issues confronting Australia, one would have thought that mathematicians and statisticians would be overwhelmed with work associated with environmental measurement, modelling and monitoring. However, if recent newspaper articles are to be believed our best and brightest mathematical brains are deserting us at an unprecedented rate (*The Age*, August 14, 2002).

Statistics has its genesis back in Roman times when information on the 'State' (typically taxes) was gathered in a systematic way. While such routine data gathering exercises still exist, the discipline of statistics embraces and is built upon advanced mathematical, computing, and probabilistic techniques. The application of these methods to help better measure, monitor, and manage our environment is unfortunately patchy. *State of Environment (SoE)* reporting at federal and state levels is now commonplace and while this is a positive and necessary step in assessing environmental condition, the '*State of Statistics*' (SoS) is languishing. Declining student numbers in mathematics courses, lack of research funds, and a general malaise for all things quantitative are cited as evidence of our national indifference to the mathematical sciences. In October 2000, the Federation of Australian Scientific and Technological Societies (FASTS) released Occasional Paper number 3 titled "Mathematical Sciences in Australia: Looking for a Future". This was an impassioned plea for increased national awareness of the relevance and importance of mathematics education through increased funding for research and teaching in the mathematical sciences. Two years down the track and not much has changed. Indeed, in its "Maths is Boring" edition of Ockham's Razor (ABC Radio, April 15, 2001) the issue of whether or not students should be required to study mathematics if they didn't think they needed to was entertained.

So why is maths perceived as boring and irrelevant to many? Why is there a major disconnect between what CSIRO's Graham Harris calls "wickedly complex" environmental problems and the level of statistical R&D devoted to their solution? While the Universities and CSIRO continue to wrestle with the identification of their respective niches ('*CSIRO – Up for Grabs*', The Science Show, ABC radio October 5, 2002) we have the federal Environment and Heritage Minister, Dr. David Kemp emphasising the need for "sound science" - particularly as it relates to things like salinity hazard mapping (keynote address AgForce State Conference, Biloela, July 29 2002). Furthermore, Dr. Kemp went on to say "Certainty in relation to the science –at least as much certainty as science is able to deliver - is an entirely reasonable demand". The issue of certainty (or more precisely, *uncertainty*) is the stuff of statistics. One would have thought that the statisticians would be having a field day in an environment characterised by high levels of uncertainty, low levels of data, and a backdrop of huge spatial-temporal variability. Alas, this is not the case. As one of my EPA colleagues remarked the other day "consulting with a statistician is like a visit to the dentist to have teeth extracted".

And therein lays a big part of the problem. Research-capable statisticians are renowned for their petulant and punitive admonishment of 'non-statisticians' who have dared collect and analyse data using statistical tools.

It's ironic that the statistics profession continues to lament its perceived undervalued, unloved status among other researchers and the broader community when it continues to slap the wrists of those seeking their wisdom. Responses of "you should have come to see me sooner" or "I can't do anything for you unless you obtain more samples" roll off the lips of many statisticians almost as often as "*p-value*" or "*unbiased estimator*". If it's any comfort, Australian Statisticians are not alone. A recent article in *The American Statistician* notes (yet again) that courses in statistics "for the most part, focus on the same methods that were taught 30 years ago". The same article cites a past President of the American Statistical Association as saying "We smell trouble all around us. Other disciplines and organisations have been seizing opportunities that should have been ours". The paranoia and preciousness among statisticians is high. Perpetual questioning of relevance with little action, uptake or results will not advance the statistician's lot and runs the risk that genuine concern will be seen as bleating.

So what can be done? Quite a lot actually. As far as the environment is concerned, there's a plethora of research challenges for Statisticians. A consequence of the outdated courses and migration of statistics education away from mathematics and statistics departments is the attendant 'straightjacket' approach to statistical application and problem-solving in the environmental sciences. Thus, on the one hand it is pleasing to see a greater awareness of the principles of statistical design among environmental scientists, it is disturbing that much of this country's critical statistical analyses underpinning major Natural Resource Management (NRM) decisions is being compromised by a lack of access to robust and contemporary statistical methodology. To overcome this, there needs to be improved coordination, communication, and collaboration between statisticians and environmental scientists. For their part, the statisticians need to adopt a more 'hands-on' approach. The environment is big place and Mother Nature does not yield to the sort of designed experimentation characteristic of controlled industrial or laboratory processes. So while it is possible to sit in an office and run computer software to help design a water quality monitoring strategy, the broader appreciation that accrues from actually getting out there and witnessing the data collection is invariably lost. As a practising Statistician who has flown down river gorges in Papua New Guinea, snorkelled in seagrass meadows in WA, and waded in the murky waters around a sewage outfall, I can attest to the value of this type of 'fieldwork'.

Commensurate with an increase in collaboration between Statisticians and researchers in the environmental, biological, and life sciences, is a need to provide statistical training that is more in step with the statistical rigour that sound environmental monitoring, sampling, and assessment demands. The 'classical' statistical methods taught in most university departments today are often-times ill suited to environmental applications. This is by virtue of data paucity, non-standard distributions of environmental variables, dependencies in space and time, and high background variation. *Environmetrics* is now a well-established discipline and is devoted to tackling precisely these sorts of issues. Currently, no Australian university offers a degree in 'Environmetrics' although the University of Melbourne is presently designing a Masters course as part of its Graduate Environmental Program. Graduates in Environmetrics will contribute to important areas of environmental research and development including:

- Development of risk-based tools for natural resource management;
- Setting statistically (and legally)defensible targets for water quality, sediment loads, nutrient concentrations etc. in the bays, estuaries and water bodies of Australia;
- Quantification of risks associated with genetically modified organisms, invasive pests, and biological threats;

- Identification of 'optimal' monitoring designs to help government agencies establish the effectiveness of large-scale remediation programs under National Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAPSWQ);
- Obtain estimates of error and uncertainty in the outputs of biophysical models such as those used to describe the areal extent of the salinity problem;
- Integration of statistical information systems (SISs) with ubiquitous GISs to provide improved representation of spatial processes;

Like the lyrics of one of my favourite songs says "*the future's so bright I've got to wear shades*" – it's time for statisticians around the country to don the Polaroids!

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